Consequences of including high levels of sorghum-based distillers dried grains with solubles (DDGS) on nursery and finishing pig diets

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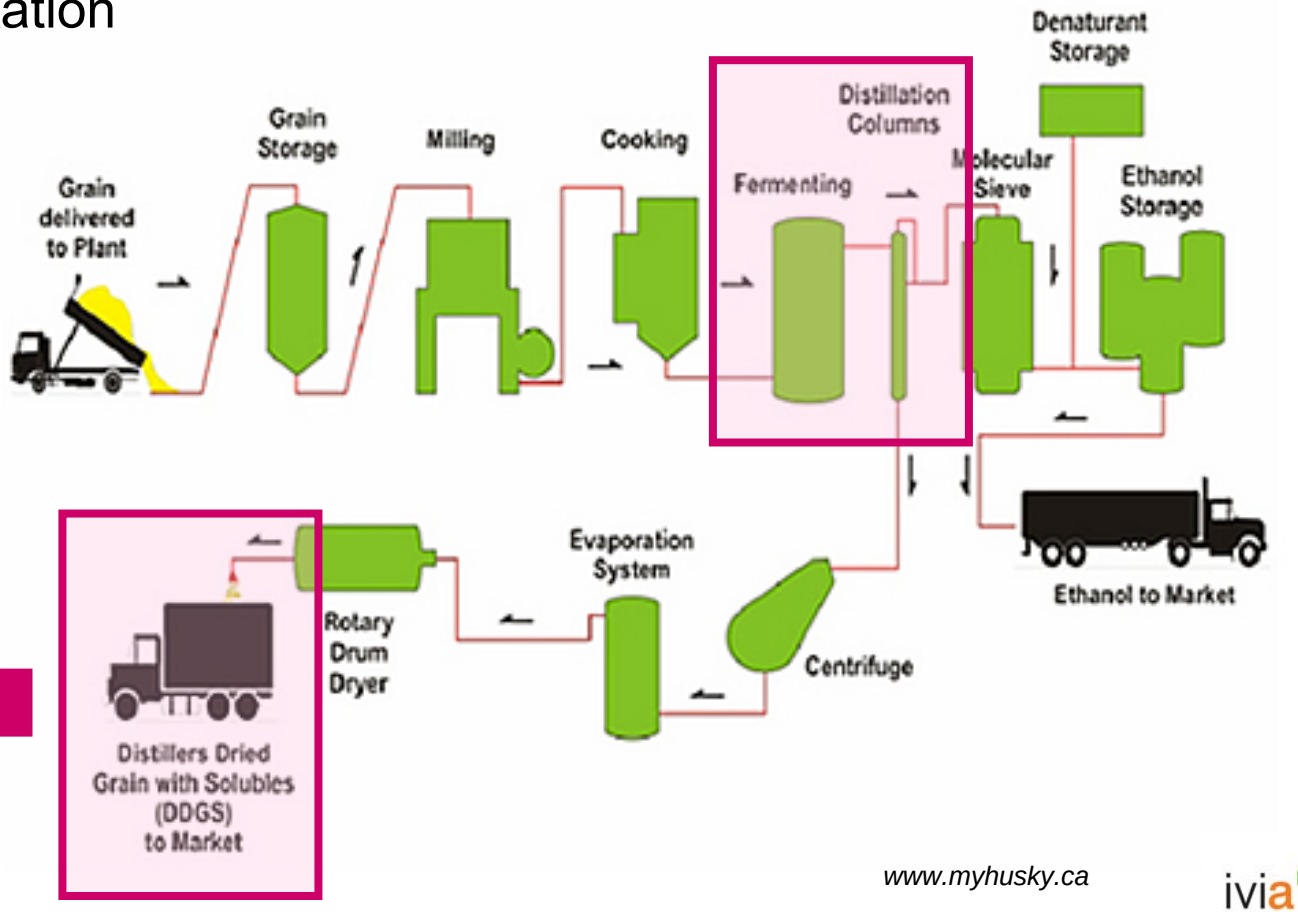
Distiller dried grains with solubles (DDGS)

- **DDGS** are produced as a co-product from the ETHANOL production from grain (cereal):

  - Alternative sources for bioethanol production: high sugar content
    - Sugar beet / sugar cane
    - Alcohol / surpluses on the wine market

BIOETHANOL production process:

Ethanol production from grain involves the conversion of **starch** to **ethanol** through fermentation



DDGS:

New ingredients for animal feeding

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BIOETHANOL production process:

Conversion rates of grains to ethanol (low efficiency, reduce CO_2 emis.):

1 tonne of CORN:

- ✓ 350-360 kg ethanol
- ✓ 310-320 kg of DDGS
- ✓ 320-340 kg CO2

Thus, **DDGS** represent 27 to 30 % of the original grain weight

DDGS *vs* grain:

- ✓ Energy: similar to grain, less starch but more protein, fat and fibre
- ✓ Protein: more protein and AA (Lys, Trp, Thr) (x3) but lower digestibility
- ✓ Minerals and vitamins: higher content (P availability)
- ✓ Antinutritional factors (tannins) and micotoxins: x3

INTRODUCTION

Main grains for bioethanol production: *Corn, wheat, barley and sorghum.*

Corn primary grain used for bioethanol (14% of the total production in U.S., 2008)

Corn plant

Sorghum grain ranks 5th in cereals for global production (FAOSTAT, 2008)

Close-up photo of sorghum head

INTRODUCTION

Main grains for bioethanol production: *Corn, wheat, barley and sorghum.*

Corn vs Sorghum

- Similar composition *vs* other cereals: energy, protein
- **Sorghum** requires less rainfall during the growing season than corn
- **Sorghum** is less competitive with human feeding than corn
- **Sorghum** (some varieties) contain tannins, reduce palatability and AA digestibility

Nutrient	Corn	Sorghum
ME, kcal/kg	3365	3230
CP, %	7.7	8.7
Lysine, %	0.22	0.20
Crude Fat, %	3.6	3.0
Crude Fibre, %	2.5	2.1
Starch, %	63.4	63.8

Source: FEDNA 2006

Bioethanol plants in Spain: 11 (165 plants in the U.S.)

	Production (MT Ethanol/year)	*Current State*	*Source*
Salamanca, Babilafuente	158.000	Production	Cereal
Teixeiro, A Coruña[1]	139.000	Production	Cereal
Cartagena, Murcia[1]	118.000	Production	Cereal
Alcázar de San Juan, Ciudad Real	26.000	Production	Wine surplus
Villarejo de Órbigo, León[2]	200	Production	Various
Barcial del Barco, Zamora	145.000	Construction	
Torrelavega, Cantabria	126.000	Construction	
Villanueva de la Serena, Badajoz	110.000	Construction	
Puertollano, Ciudad Real	150.000	In project	
Zierbana, Vizcaya	126.000	In project	
Miranda de Ebro, Burgos	65.000	In project	
Total	1.363.000		

[1]*Sorghum*
[2]*Experimental plant*

Source: BioDieselSpain.com

INTRODUCTION

Feeding value of DDGS for PIGS:

Inclusion level of DDGS depends on (Stein, 2007; Applegate et al. 2008; Linneen et al., 2008; Young, 2008; Urriola et al., 2009):

- ***Nutrient composition*** (quality of the drying process and cereal):
  - *Energy content*
  - *Protein and AA content and availability:* between 43.9 – 77.9 % (Stein et al., 2006). Imbalanced AA profile.
  - *Others*: **tannins**, mycotoxins (**palatability and VFI**)
  - **Fiber content**: lower carcass yield?
  - **Fat content** (unsaturated fatty acids): less firm fat
- ***Age:*** younger less fermentation capacity (fiber)

INTRODUCTION

Feeding value of DDGS for PIGS:

Inclusion levels of DDGS:

variable results in the literature

Phase	DDGS source	Inclusion levels	Comments	References
Nursery pigs (> 7 kg)	***Corn***	10-15% up to 25-30%	1-2 weeks acclimation period	*Gaines et al. (2006), Spencer et al. (2007) Young et al. (2008)*
	Sorghum	Less than corn, up to 25%		*Senne et al. (1996), Feoli et al. (2008)*
Finishing pigs	***Corn***	Up to 35-40%	Attention to dressing percentage and carcass fat	*Widmer et al. (2008), Drescher et al. (2008)*
	Sorghum	Up to 30%		*Senne et al. (1998), Feoli et al. (2008)*

OBJECTIVE

Evaluate the consequences of feeding high levels of DDGS from sorghum grains to pigs on growth performance, body composition and carcass yield.

MATERIALS AND METHODS

- ✓ Nursery and growing-finishing pigs (blocked by body weight and sex):
  - ***Nursery:*** 204 pigs (12-14 animals/pen; 16 pens); 13.9 ± 2.60 kg
  - ***Growing-finishing pigs:*** 194 (5 animals/pen; 38 pens); 38.9 ± 6.33 kg

MATERIALS AND METHODS

✓ Nursery and growing-finishing pigs

✓ Treatments (DDGS single source)

– ***Nursery (28 days)***

- CONTROL diet: commercial corn/soybean meal feed
- DDGS diet: **15%** sorghum-based DDGS feed

– ***Growing-finishing (70 days)***

- CONTROL diet: commercial corn/soybean meal feed
- DDGS diet:
  - Early (40 to 80 kg BW): **30%** sorghum-based DDGS
  - Late (80 to 110 kg BW): **35%** sorghum-based DDGS

MATERIALS AND METHODS

✓ Diets (nutrient calculated composition):

	NURSERY		EARLY GROWING-FINISHING		LATE GROWING-FINISHING	
Nutrient	**Control**	**15DDGS**	**Control**	**30DDGS**	**Control**	**35DDGS**
ME, kcal/kg	3315.6	3267.2	3236.8	3165.9	3176.6	3078.8
CP, %	19.0	18.9	16.0	16.5	16.2	16.9
Lysine, %	1.33	1.32	1.01	1.00	0.96	0.95
CFat, %	7.0	8.4	5.8	8.2	7.0	9.6
CFibre. %	3.1	3.5	3.7	4.0	4.7	5.1
Ash, %	5.4	5.5	4.7	4.7	5.2	5.4

MATERIALS AND METHODS

✓ Measurements:

- ***Productive performance*** during nursery (every week) and growing phases (every two weeks):
  - ADG
  - ADFI
  - G:F
  - Health status/mortality

- ***Backfat and loin depth*** (P2 level, Agroscan A16, Angoulême, France) at the end of the study
- ***Carcass weight and carcass yield*** at slaughter
- ***Laboratory analyses DDGS composition***:
  - Weende, Van Soest and AA

RESULTS

DDGS composition

RESULTS
DDGS composition

✓ Sorghum based DDGS composition:

Sorghum-based DDGS

RESULTS
DDGS composition

✓ Sorghum based DDGS composition:

Nutrient, %	Sorghum-DDGS		Sorghum grain[1]
DM	90.2		86.8
CP	33.7		8.7
CFat	10.8		3.0
CFibre	5.4	x 3	2.1
NDF	26.5		9.0
ADF	8.8		3.8
ADL	0.7		0.7
Ash	4.9		1.3

[1]FEDNA (2006)

RESULTS
DDGS composition

✓ Sorghum based DDGS composition:

Nutrient, %	Sorghum-DDGS	Corn-DDGS[1]
DM	90.2	86.0
CP	33.7	24.5
CFat	10.8	9.8
CFibre	5.4	8.0
NDF	26.5	36.9
ADF	8.8	12.5
ADL	0.7	3.0
Ash	4.9	5.8

[1]FEDNA (2006)

RESULTS
DDGS composition

✓ Sorghum based DDGS composition:

Nutrient, %	**Analyzed sorghum-DDGS**	**Assumed sorghum-DDGS**
DM	90.2	89.0
CP	33.7	27.5
Lysine	0.70	0.59
Crude Fiber	5.4	6.5
Ether extract	10.8	8.0

Assumed composition of DDGS underestimated DDGS analytical composition and nutrient value

RESULTS
DDGS composition

✓ Sorghum based DDGS AA composition:

AA, %CP	Sorghum-DDGS	Sorghum grain[1]
Lys	2.08	2.34
Met	1.83	1.72
Met+cys	3.55	3.56
Thr	3.09	3.45
Ile	3.70	4.14
Val	4.72	5.18

[1]FEDNA (2006)

Balanced AA profile

RESULTS
DDGS composition

✓ Sorghum based DDGS AA composition:

AA, g/100gDM	Sorghum-DDGS	Sorghum grain[1]
Lys	0.70	0.20
Met	0.62	0.15
Met+cys	1.20	0.31
Thr	1.04	0.30
Ile	1.25	0.36
Val	1.59	

x 3

[1]FEDNA (2006)

Stein (2007): Corn DDGS when lysine to protein ratio ≥ 2.80 good quality DDGS

Sorghum DDGS : 2.08% (Urriola et al., 2009)

RESULTS

Growth performance

RESULTS
Growth performance

✓ **Growth performance**: **Nursery period** (28 days)

- ✓ 6 pigs dead, all from the C group
- ✓ No sex and T*sex effect (P>0.10)
- ✓ Total growth performance:

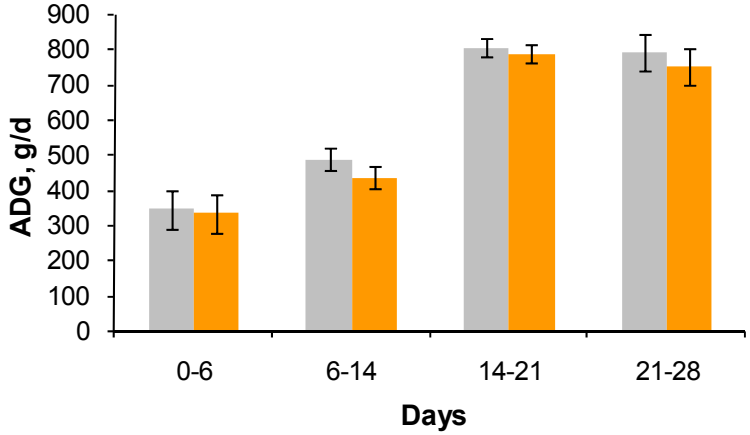
Treatment	Initial wt, kg	Final wt, kg	ADG, g/d	ADFI, g/d	G:F
Control	13.8	31.0	597.5	951.1	0.63
15DDGS	14.0	30.0	578.7	871.4	0.66
SEM	*0.76*	*0.34*	*23.86*	*31.24*	*0.022*
P-value (T)	*0.842*	*0.081*	*0.587*	*0.097*	*0.289*

Negative effects on feed intake and final weight (tendency, P<0.10)

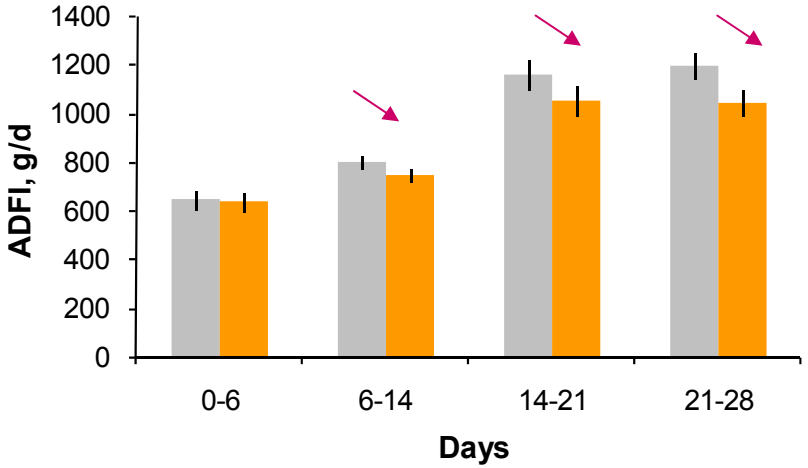
RESULTS
Growth performance

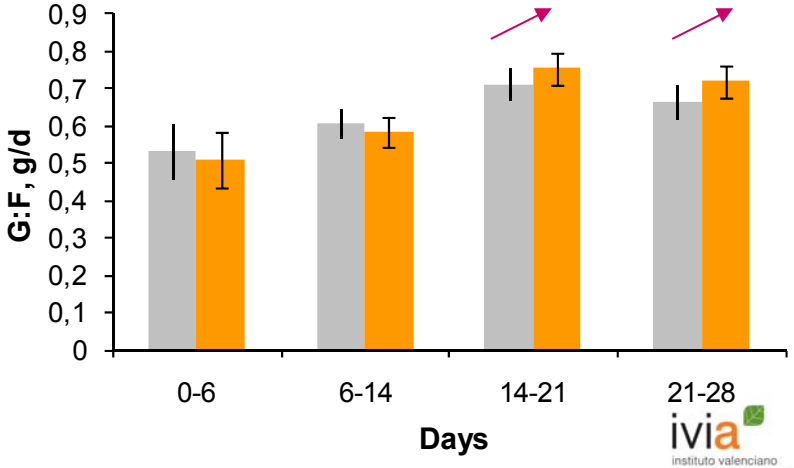
✓ **Growth performance**: **Nursery period** (28 days)

✓ By period



P<0.10





Lower feed intake during all the growing period.

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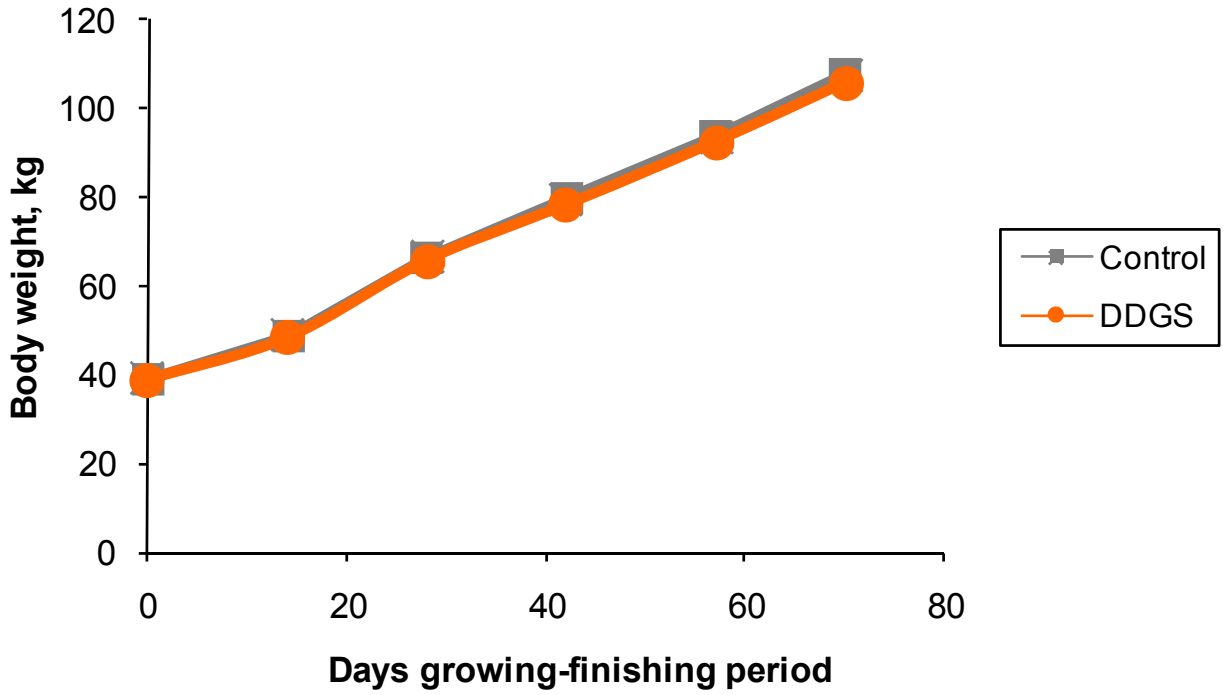
RESULTS
Growth performance

- ✓ **Growth performance**: **Growing-finishing** (70 days)
  - ✓ NO pigs dead; NO T*sex effect (P>0.10)
  - ✓ Total growth performance: no differences

Treatment	Initial wt, kg	Final wt, kg	ADG, g/d	ADFI, g/d	G:F
Early period					
Control	39.0	79.5	972.9	1247.8	0.78
30DDGS	38.9	78.4	908.1	1202.8	0.76
SEM	*1.35*	*2.08*	*24.00*	*34.45*	*0.018*
P-value	*0.957*	*0.707*	*0.064*	*0.361*	*0.333*
Late period					
Control	79.5	*107.6*	940.3	2617.0	*0.36*
35DDGS	78.4	*105.9*	978.0	2547.2	*0.38*
SEM	*2.08*	*2.27*	*29.42*	*39.83*	*0.012*
P-value	*0.707*	*0.595*	*0.370*	*0.222*	*0.145*

RESULTS
Growth performance

- ✓ **Growth performance**: Growing-finishing (70 days)
  - ✓ By period: evolution of individual pig weight



RESULTS
Growth performance

✓ **Backfat and loin depth** at the end of the study

Treatment	Backfat, mm	Loin depth, mm
Control	9.80	51.67
DDGS	10.96	50.92
SEM	0.233	0.594
P-value (T)	<0.001	0.362

RESULTS
Growth performance

✓ **Backfat and loin depth** at the end of the study

Treatment	Backfat, mm
Control	9.80
DDGS	10.96
SEM	0.233
P-value (T)	<0.001

Literature: no differences in BF

Difference between assumed and analysed DDGS??

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RESULTS

Carcass quality

RESULTS
Carcass quality

✓ **Carcass weight and yield** at slaughter

Treatment	Carcass wt, kg	Carcass yield, %
Control	91.4	76.5
DDGS	90.0	76.0
SEM	1.363	0.406
P-value (T)	0.413	0.367

No significant differences due to high fibre content in DDGS diet as in other studies (Cook et al., 2005 and Withney et al., 2006).

CONCLUSIONS

- ✓ Inclusion of **15% sorghum-based DDGS** in **nursery** diets (14 to 31 kg) tended to reduce voluntary feed intake and weight gain.

- ✓ As much as **30%** to **35% sorghum-based DDGS** in diets for **finishing** (40 to 107 kg) pigs caused:

  - ✓ No negative effects on ADFI and growth performance.
  - ✓ High backfat levels (≈ 1 mm)
  - ✓ No effects on carcass weight and yield.

Final remark

- ✓ It is necessary to elaborate a DDGS nutrient databases in order to optimize diet formulation with DDGS.

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